Aeroelastic Stability Testing

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An important consideration in the design of helicopter rotor blades is the stability of the isolated rotor and the coupled rotor-body system. Once disturbed, unstable linear systems grow in response without bound until a failure occurs. Therefore, the helicopter design engineer would like an analytical tool that would accurately calculate the stability of these systems. The present work provides an experimental database that is needed to validate these analytical tools. The database, when complete, will include two rotor-blade configurations tested in hover and forward flight. This year's accomplishments include the fabrication and structural testing of the second rotor-blade configuration.

The two configurations include a rectangular blade with center of gravity, elastic axis, tensile axis, and aerodynamic center located on the quarter chord, and a swept-tip blade with small offsets in elastic and inertial properties. The rectangular blade is the simplest of the two structures to analyze. The more complicated swept tip amplifies the coupling of bending and torsion modes. Both blade sets have a hingeless hub design (root pitch motion through a feathering bearing; flap and in-plane motion through a composite root flexure). The rotors are mounted on a relatively rigid test stand to confine the experiment to the physics of interest. Once the operating condition is obtained, hydraulic actuators are used to oscillate the pitch of the blade at the regressive in-plane mode natural frequency, thus exciting this lowly damped mode. The excitation is shut off and the decay of the in-plane bending moment is measured by strain gages bonded to the blade structure. The rectangular-bladed rotor has been tested in hover by varying rotor speed and collective pitch and in forward flight by varying wind speed, collective pitch, and shaft angle at 1700 revolutions per minute.

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Flight Mechanics of Helicopter Sling-Load Systems

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The specific objectives of this research are (1) to develop and demonstrate the ability to compute the dynamic flight envelope of helicopter and sling-load combinations simultaneously with flight testing, and (2) to develop corresponding simulation models validated with flight-test data.

Helicopter sling-load operations are common in both military and civil operations. The addition of the load can degrade system stability and reduce the safe operating envelope of the combined system below that of the helicopter alone. During its operational life, a utility helicopter will carry a wide variety of loads using a variety of slings, each with different dynamic characteristics. Incidents and accidents can occur when the dynamic limits of the helicopter and load are unknowingly exceeded. To avoid these occurrences, military helicopters and loads are usually qualified for these operations in flight tests, which can be expensive, time consuming, and sometimes risky.

The cost, time, and risks of flight qualification tests can be reduced by developing a system providing real-time analysis of flight-test data. Quantitative assessment of helicopter flying qualities and load-pendulum stability can be accomplished after a test